SYSTEM DEVELOPMENT WORKING GROUP REPORT

William Smith, Chairman
TRW Space and Technology Group

William Bifano, Cochairman
NASA Lewis Research Center

Introduction

The System Development Working Group's output was highly dependent upon the parallel working group sessions in the spacecraft system and subsystems areas. As such, a deliberate attempt was made to have working group members interact with the other working groups. However, due to the time lag of some of the other working groups' actions, the key technologies shown for analysis are as of late Wednesday afternoon of the workshop.

The charter of the System Development Working Group is shown in Figure 1. The objective of the System Development Working Group was to recommend an approach to technology validation and in-space system technology demonstration. In addition, this working group was charged with making a unique recommendation relative to the evolution of automation and robotics. The readers of this proceedings will note that automation and robotics really is distributed in a number of the working group reports. Therefore, the System Development Group decided to focus their attention on telerobotic evolution for the Spacecraft 2000 infrastructure.

The System Development Working Group carried the following assumptions through their working group deliberations:

1. No launch vehicle constraints
   - All the national launch systems capabilities are available.
2. STS and Space Station are available for use as in-space test beds.

3. Orbital serviceability had reached maturity and was available.

4. NASA/DOD national test beds are available on a cooperative, non-interference basis.

In addition, the working group felt it should take advantage of existing and planned NASA and DOD in-space facilities and systems in conducting the proposed in-space testing.

The key issue in the System Development Working Group was: how do you get new technology introduced into systems without increasing program risk? The Spacecraft 2000 thrust must permit introduction of highly leveraged technology which is mature with well understood technical and programmatic risk.

Spacecraft 2000 Key Technologies

The Spacecraft 2000 key technologies in priority order are listed in Figures 2 and 3; there was a forced choice imposed by the System Development Working Group in that we asked each working group to give us their top three. In a few instances they coalesced on four recommended technology areas. As a reminder, there is the caveat of the time lag relative to the final disposition of the various working groups' technology listings.

Generic Spacecraft 2000 - Test Bed Philosophy

The need for a generic Spacecraft 2000 test capability presented by a member of the System Development Group, Jim Loos of Lockheed, was accepted as a working philosophy. Figure 4 represents the ground and space segment test philosophy which is integral to our recommendations.

Test Bed Requirements Analysis

The System Development Group performed a top level analysis of ground and in-space test requirements relative to the other working groups high priority technology areas. Figures 5 and 6 depict the summarization of that analysis. Under ground test capability, the "E" represents existing and "N" equals new. The in-space test requirements were analyzed around major

capabilities of the Space Transportation System (STS), Space Station (SS), and Free Flyer (FF). The need for a space test free flyer capability became evident from this preliminary top level analysis.

Space Test Bed Characteristics

The System Development Working Group developed a list of key space test capability characteristics which are shown in Figure 7. Since the characteristics are self-explanatory, no further discussion is necessary.

Summary

The critical need, as shown in Figure 8, is the need for funding and testing as bridging support for Spacecraft 2000 highly leveraged technology to promote flight development introduction and acceptance. We need to make use of all existing test capabilities. However, we foresee critical needs to augment these capabilities to satisfy specific enabling technology validation and to flight qualify selected technologies.

Recommended Actions

Figure 9 summarizes the System Development Working Group's recommendations. We believe OAST has a unique NASA leadership opportunity to promote timely and effective technology transition.

Acknowledgements

Figure 10 lists the System Development Working Group membership. The working group would like to express its appreciation to LeRC and OAST for their foresight and leadership in conducting this timely workshop and to their NASA colleagues for their support.

SYSTEMS DEVELOPMENT W/G OBJECTIVE/ASSUMPTIONS/KEY ISSUES

OBJECTIVE:
- RECOMMEND APPROACH TO TECHNOLOGY VALIDATION AND IN-SPACE SYSTEM TECHNOLOGY DEMONSTRATION

ASSUMPTIONS:
- NO LAUNCH VEHICLE CONSTRAINTS
- STS AND SPACE STATION AVAILABLE FOR IN-SPACE TEST BEDS
- SERVICEABILITY IN PLACE
- NASA/DOD NATIONAL TEST BEDS AVAILABLE (NON-INTERFERENCE)

KEY ISSUES:
- HOW DO YOU GET NEW TECHNOLOGY INTRODUCED INTO SYSTEMS WITHOUT INCREASING PROGRAM RISK?

FIGURE 1

SUBSYSTEMS W/G	KEY TECHNOLOGIES
• SPACECRAFT SYSTEM	1. STRUCTURAL CONTROLS INTERACTION
	2. ADVANCED THERMAL CONTROL
	3. ELECTRIC PROPULSION
	4. NUCLEAR POWER SYSTEM
• PROPULSION	1. ADVANCED BIPROPELLANTS
	2. ELECTRIC PROPULSION
	3. FEED SYSTEMS
• ELECTRICAL POWER	1. HIGH VOLTAGE POWER SYSTEMS
	2. DYNAMIC POWER SYSTEMS (SOLAR & NUCLEAR)
	3. HIGH FREQUENCY POWER SYSTEMS
	4. ADVANCED SOLAR ARRAYS
• THERMAL CONTROL	1. ADVANCED HEAT PIPES
	2. ADVANCED FLUID HEAT TRANSFER SYSTEMS
	3. ADVANCED PASSIVE THERMAL CONTROL SYSTEMS

FIGURE 2.

SUBSYSTEMS W/G	KEY TECHNOLOGIES
• TT & C/COMM	1. MICROWAVE COMPONENTS
	2. LOW-COST TEST TECHNIQUES
• DATA MANAGEMENT	1. FAULT TOLERANCE
	2. 10 MOPS SPEED
	3. HIGHER SPEED DATA TRANSMISSION
	4. ON-BOARD DATA STORAGE
• ATTITUDE CONTROL	1. ACS VALIDATION AND TEST
	2. FLEXIBLE STRUCTURE CONTROL
	3. ACS AUTONOMY
	4. LOW NOISE SENSORS AND ACTUATORS
• STRUCTURES & MATERIALS	1. ADVANCED MATERIALS & CHARACTERISTICS
	2. TEST/QUALIFICATION/VERIFICATION METHODS
	3. ZERO-GRAVITY OPERATIONS (ASSEMBLY, PROCESSING, JOINTS/CONNECTORS)
• TELEROBOTICS	1. ZERO-G MANIPULATION
	2. SYSTEM PERFORMANCE VALIDATION
	3. S/C 2000 TEST BED FACILITATOR

FIGURE 3

SPACECRAFT 2000 - TEST BED PHILOSOPHY

GROUND SEGMENT

- INDUSTRY RESOURCES FOR DEVELOPMENT

  EXCEPT

- GOVERNMENT FURNISHED FOR UNIQUE/EXPENSIVE FACILITIES AND INTERFACING/RELATED COMPONENTS IN A STANDARDIZED ENVIRONMENT FOR EVALUATION

SPACE SEGMENT

- TOO COSTLY FOR INDUSTRY
- VALIDATES AVAILABLE TECHNOLOGY (SPACE QUALIFIED)
- ADAPTABLE TEST BED(S) (CONFIGURATION AND LAUNCH VEHICLE INTERFACE)

FIGURE 4

		TEST BEDS				
		GROUND	SPACE			
			STS		SS		FF
SPACECRAFT SYSTEMS	1.	E					X
	2.	E	X	OR	X	OR	X
	3.	E					X
	4.	E & N					X
PROPULSION	1.	E					
	2.	E & N					X
	3.	E	X	OR	X	OR	X
ELECTRIC POWER	1.	E	X	OR	X	AND	X
	2.	E & N			?		X
	3.	E					X
	4.	E	X	OR	X	OR	X
TELEROBOTICS	1.	E	X	OR	X		
	2.	E	X	OR	X		
	3.	E					X
THERMAL CONTROL	1.	E	X	OR	X	OR	X
	2.	E & N			X	OR	X
	3.	E			X	OR	X

FIGURE 5

		TEST BEDS (CONT'D)				
		GROUND	SPACE			
			STS		SS		FF
TT&C/COMMUNICATIONS	1.	E	X	OR	X	OR	X
	2.	E					
DATA MANAGEMENT	1.	E					
	2.	E					
	3.	E					
	4.	E			X	OR	X
ATTITUDE CONTROL	1.	E & N					X
	2.	E & N					X
	3.	E					?
	4.	E					X
STRUCTURES/MATERIALS	1.	E					X
	2.	E & N					X
	3.						

FIGURE 6

SYSTEM DEVELOPMENT

SPACE TEST BED CHARACTERISTICS

- FREE FLYING TEST CAPABILITIES
- CAN BE DECOUPLED FROM SPACE STATION AND STS (OPERATIONALLY AND PROGRAMMATICALLY)
- INSTRUMENTED FOR ENVIRONMENT AND OPERATING PARAMETERS
- RECONFIGURABLE FOR UNIQUE SINGLE AND COMBINATIONS OF SUBSYSTEM TESTING
- RETRIEVABLE/REVISTABLE/SERVICEABLE
- DEVELOPED AND OPERATED BY GOVERNMENT

FIGURE 7

SUMMARY

- NEW HIGHLY LEVERAGED TECHNOLOGY NEEDS BRIDGING SUPPORT
- FLIGHT USE OF TECHNOLOGY REQUIRES ACCEPTABLE RISK
  - GROUND AND SPACE TESTING REQUIRED (FOR USER ACCEPTANCE)
  - (SELECTIVE) FLIGHT QUALIFICATION REQUIRED

FIGURE 8

RECOMMENDED ACTIONS

- OAST TAKE ON NASA ROLE OF FLIGHT VALIDATION OF SPACE SYSTEMS TECHNOLOGY
- OAST ADVOCATE AN INITIATIVE (SPACECRAFT 2000) THAT INCLUDES SPACE TEST CAPABILITY
- OAST EXPLORE INDUSTRY AND INTERAGENCY AGREEMENTS FOR UTILIZATION OF NATIONAL TEST BED CAPABILITIES

FIGURE 9

SYSTEM DEVELOPMENT WORKING GROUP MEMBERSHIP

INDIVIDUAL	ORGANIZATION
W. J. BIFANO	NASA/LEWIS RESEARCH CENTER
D. BURROWBRIDGE	SPERRY CORP., SPACE SYSTEMS DIVISION
R. A. CLIFF	DARPA
R. A. DALEBOUT	GTE SPACENET INC.
D. C. FERGUSON	NASA/LEWIS RESEARCH CENTER
LT. COL. E. JONSON, USAF	AIR FORCE GEOPHYSICS LABORATORY
J. E. LOOS	LOCKHEED MISSILES AND SPACE COMPANY
D. H. MITCHELL	TRW SPACE AND TECHNOLOGY GROUP
M. E. PEREZ-DAVIS	NASA/LEWIS RESEARCH CENTER
D. L. PIVOROTTO	JET PROPULSION LABORATORY
B. RAAB	FAIRCHILD SPACE COMPANY
R. E. REYES	NASA/KENNEDY SPACE CENTER
W. L. SMITH	TRW SPACE AND TECHNOLOGY GROUP

FIGURE 10